THE PROGRESSIVE FISH CULTURIST

NEWS AND VIEWS FROM MANY SOURCES ON PRACTICAL HATCHERY PROBLEMS

ISSUED BY THE

BUREAU OF FISHERIES, U. S. DEPARTMENT OF COMMERCE

FEBRUARY 1937

WASHINGTON

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The PROGRESSIVE FISH CULTURIST is a serial memorandum prepared by the Division of Scientific Inquiry under the editorship of Elmer Higgins, Chief of the Division, and H. S. Davis, In Charge of Aquicultural Investigations, and is distributed free of charge on regular mailing lists. Applications for this memo should be addressed to the Commissioner of Fisheries, and contributions for publication directed to the Editor, P. F. C., Bureau of Fisheries, Washington, D. C. Articles on any subject related to fish culture and criticisms or comments are welcome.

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Memorandum I-131 Washington, D. C. February 1937 No. 27.

COLD STORAGE PLANTS AT OREGON TROUT HATCHERIES

By Matt L. Ryckman
Superintendent of Fisheries, Oregon State Game Commission

WITH THE STRESS on sport fishing in the State of Oregon annually becoming greater, the Oregon State Game Commission was faced with the necessity of providing more efficient methods of dealing with its trout food supply, to the end that the streams and lakes of the state may be more adequately stocked. The increased production of trout made more difficult a problem with which the Commission had already been confronted, that of providing its hatcheries with a daily supply of fresh food.

In Oregon, trout propagation is carried on at sixteen separate hatcheries located in various parts of the state, many of them situated miles from a railway. The feed used at these hatcheries consists of salmon eggs, salmon flesh, trash fish, and lungs, spleen, hearts and liver. As a rule it is the plan to keep a year's supply ahead, and this means that the feed must of necessity be kept in cold storage. Since the hatcheries are in most instances at a considerable distance from commercial cold storage plants, it followed that feed for these stations had to be sent in several times a week in small quantities, and often much of it was lost through spoilage before it could be used. Renting cold storage facilities in the nearest town was tried but the rent of such cold storage space added to the original cost of the feed made the total cost prohibitive.

If the feed was not kept in cold storage, purchasing in small quantities was unavoidable, with the result that much higher prices had to be paid than if the purchases were made in large quantities. All of this suggested the advisability of providing individual cold storage plants at each hatchery.

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Altogether, the Oregon Game Commission has thirteen of its sixteen fish hatcheries equipped with cold storage plants having a combined capacity of 440 tons, and so successful and satisfactory has this system of individual cold storage plants proven that the three remaining hatcheries will be provided with plants as soon as funds are available.

NOTES ON THE USE OF KELP MEAL IN THE DIETS OF YOUNG SALMON

By L. R. Donaldson, Department of Fisheries, University of Washington, and Fred J. Foster, U. S. Bureau of Fisheries, Seattle, Washington.

KELP MEAL has been used in animal feeding for a number of years to provide additional vitamins and minerals in the diet. The kelp provides a convenient way of adding vitamin B, and more important perhaps, a natural, vegetable form of iodine. Iodine is becoming a recognized essential in fish diets, where it is used as a preventative or cure for goiter.

During the 1936 season experiments were conducted, with small amounts of kelp in the diet, at the Clackamas Station of the U. S. Bureau of Fisheries using young chinook salmon as test animals, and at the Quilcene Station of the Bureau where young silver (coho) salmon were fed experimentally.

The kelp meal used in both experiments was furnished, without charge, by Mr. S. E. Briggs, representing the Kelco Company, San Diego, California. This meal was prepared from the giant kelp (Macrocystis pyrifera) by drying the harvested kelp and then grinding the resultant product into meal. In computing the cost of producing a pound of fish, the kelp meal was considered to have cost $.035 per pound.

CLACKAMAS EXPERIMENT

The Clackamas experiments were conducted in standard hatchery troughs for the first two months and circular tanks the third month. Spring water at a constant temperature of 52°F. was supplied. The experiments were started as soon as the yolk sac was completely absorbed. Two thousand young chinook salmon (Oncorhynchus tschawytscha) were used in each lot.

The growth in average weight of the fish in this group of experiments is shown in Table I. The control lot, No. 1, was fed beef spleen exclusively. Lot No. 12 received a mixed diet of 3 percent spleen, 40 percent oat mush (1 part by weight of oat flour cooked with 4 parts by weight of water), 20 percent air-dried salmon meal (Quilcene), and 10 percent ground water cress. Lot No. 13 received the same mixture as lot No. 12 except that the water cress was replaced by 2 parts of kelp meal that was soaked in 8 parts of water prior to mixing with the balance of the diet.

The fish in lot No. 13, fed the combination diet with the supplement of kelp meal, produced the best growth during the three months time, increasing 503 per cent in weight, (Table I). The mortality was also the lowest of any of three lots with a total of 4.4 percent. The utilization of food was the highest of any of the lots with an efficiency of .294 or 3.4 pounds of good required to produce a pound of fish at a cost of $.067 a pound. The combination diet with the water cress supplement fed to the fish in lot No. 12 proved to be inferior to the diet with the kelp meal supplement. The fish in this lot increased 439 percent in weight in three months. The mortality rate of 10.6 percent was also in excess of that in lot No. 13. The utilization of food was slightly inferior to that obtained in lot No. 13 with 4.0 pounds of food required to produce one pound of fish at a food cost of $.076 for each pound of fish produced.

The fish in the control group fed solely on beef spleen, produced inferior growth to that produced by the fish fed the combination diets, Nos. 12 and 13, increasing 396 percent in weight in three months. The mortality for this lot was 5.4 percent. The utilization of food was also inferior to that obtained with the combination diets, with 4.7 pounds of food required to produce one pound of fish, at a food cost of $.154 for each pound of fish produced.

QUILCENE EXPERIMENTS

The Quilcene experiments were conducted with 2,000 silver salmon (Oncorhynchus Kisutch) fingerlings in each lot. The experiments started as soon as the fish had completely absorbed the yolk sac and were continued for twenty four weeks.

The water supply used was derived from Penny Creek and contained some natural fish food. The temperature during the experiment ranged from about 46°F to 50°F.

A summary of the results of the experiment is given in Table II.

The control lot, No. 1, received beef liver exclusively. Lot No. 6 received a mixed diet of 60 percent beef liver and 40 percent by weight of air-dried salmon meal. The two components of the diet were thoroughly mixed before feeding. The fish in lot No. 7 received a basic diet exactly the same as those in lot No. 6 except that 2 parts of kelp meal were added to the liver-salmon meal mixture.

The mortalities in the three lots were so low in each case as to be almost ignored; only 7 of the original 2,000 fish died in lot No. 1; 8 in lot No. 6; and 9 in lot No. 7.

In the 24 weeks the experiment was in progress the fish in lot No. 1 increased 1107 percent in weight and required 3.03 pounds of liver to produce a pound of fish at a cost of $.121 a pound. The fish in lot No. 6, fed a mixed diet of liver and salmon meal, increased 1620 percent in weight, and required 1.69 pounds of the mixed food to produce a pound of fish, at a cost of $.068 a pound for the fish produced. The fish that received the kelp supplement, lot No. 7, increased 1707 percent in weight during the feeding trials, and required 1.67 pounds of food to produce a pound of fish, at a cost of $.068 a pound for the fish produced.

TABLE I. SUMMARY OF EXPERIMENTAL TESTS WITH CHINOOK SALMON FINGERLINGS AT THE CLACKAMAS STATION, U. S. BUREAU OF FISHERIES

Date experiment started: January 3, 1936. Concluded: March 31, 1936.

Initial number of fish per trough: 2000. Average water temperature: 52°F.

Lot No.	Diet	Initial length av. cms.	Final length av. cms.	Per cent gain	Initial av. wt. grams	Final av. wt. grams	Per cent gain in wt.	Mortality No.	Percent Mortality	Total Food in grams	Efficiency Factor	Lbs. of Food per lb. fish	Cost per lb. of Fish
1	100% beef spleen	3.34	6.20	85.6	.464	2.30	396	107	5.4	16,245	.214	4.7	$.154
12	30% beef spleen 40% oat mush 20% salmon meal 10% water cress	3.34	6.20	85.6	.464	2.50	439	212	10.6	14,525	.251	4.0	.076
13	30% beef spleen 40% oat mush 20% salmon meal 10% kelp & water	3.34	6.43	92.5	.464	2.80	503	88	4.4	15,200	.294	3.4	.067

Cost of foods used:

Beef spleen	$0.0325 a pound
Salmon meal (Quiloene)	$0.04 a pound
Oat flour	.015 "
Water cress	.00
Kelp meal	.035 "

Oat mush - 1 part oat flour by weight cooked with 4 parts water.

Kelp meal - 1 part kelp meal by weight soaked in 4 parts water.

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TABLE II. SUMMARY OF EXPERIMENTAL TESTS WITH SILVER SALMON FINGERLINGS AT THE QUILCENE STATION, U. S. BUREAU OF FISHERIES

Date Experiment Started: April 11, 1936. Concluded: September 25, 1936.

Initial number of fish per trough: 2000. Average water temperature: 52°F.

Lot No.	Diet	Initial length av. cms.	Final length av. cms.	Per cent gain	Initial av. wt. grams	Final av. wt. grams	Per cent gain in wt.	Mortality No.	Percent Mortality	Total Food in Grams	Efficiency Factor	Lbs. of Food per lb. of Fish	Cost per lb. of Fish
1	100% beef liver	3.2	7.12	122.5	.45	5.43	1107	7	0.35	30,422	.33	3.03	$0.121
6	60% beef liver; 40% salmon meal	3.2	8.12	153.8	.45	7.74	1620	8	0.40	24,515	.59	1.69	.068
7	60 parts liver; 40 parts salmon meal; 2 parts kelp meal	3.2	8.13	154.1	.45	8.13	1707	9	0.45	25,492	.60	1.67	.068

Costs of foods used: Beef liver $0.04 a pound
Salmon meal (Quilcene) $0.04 a pound
Kelp meal 0.035 "

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SUMMARY

Combination diets of dried salmon meal, oat mush, beef spleen, with supplements of water cress and kelp meal, fed to young chinook salmon held in spring water, produced growth superior to that of a 100 percent beef spleen diet and at less cost for the fish produced.

The addition of 2 percent kelp meal to the diet proved to be beneficial in reducing the mortality, increasing the rate of growth, and reducing the cost per pound of fish produced when compared with a similar diet supplemented with 10 percent fresh water cress.

The addition of 2 parts kelp meal to the diet of young silver salmon held in creek water increased the rate of growth only slightly over a similar lot of fish that did not receive the kelp meal. This indicates in the Quilcene test that the young silver salmon did not respond to a very marked degree to the addition of the kelp meal, or that the basic diet plus the natural food obtained from the stream water supply was ample to supply the needs of the fish.

NOTE: Experiments with rainbow fingerlings at the Bureau's hatchery at Leetown, W. Va. in 1933 showed beneficial results from the inclusion of kelp meal in the diet. These experiments were started on May 5 with fish of approximately the same size in each lot. At the conclusion of the experiment on September 23, the average individual weight of fish on a diet composed of 70 percent beef liver and 30 percent cottonseed meal was 9 grams, while those fed kelp meal in addition (70 percent beef liver, 25 percent cottonseed meal, 5 percent kelp meal) averaged 12.1 grams in weight. In contrast, fish on a straight diet of beef liver showed an averaged weight of 13.8 grams while those on a diet composed of 70 percent beef liver and 30 percent salmon egg meal averaged 17.4 grams in weight.

The mortality among the fish fed beef liver and cottonseed meal was 148 while among those receiving kelp meal it was only 26. It is interesting to note that the mortality in the lot fed beef liver and salmon egg meal was 24, two less than in the lot on the kelp meal diet.

Editor

A GILL DISEASE OF THE SMALLMOUTH BLACKBASS

By H. S. Davis, U. S. Bureau of Fisheries

ON SEVERAL occasions reports have been received to the effect that bass were affected with a gill disease, similar to the well known disease so prevalent in trout. Since there is no evidence that the bacteria that produce gill disease in trout can develop on bass, these reports have not been taken very seriously. However, in May, 1936, there was considerable mortality among the smallmouth bass in a pond at the

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Bureau's Leetown (W. Va.) experimental hatchery. The losses occurred among both brood fish and fry at about the time the latter were rising from the nests. The trouble was traced to an infection of the gills, but it was found that the causative organism was not a bacterium but a protozoan which was present on the gills in enormous numbers. These protozoans are entirely different from any previously reported on bass - or other fish for that matter - and belong to a group known as the Suctoria.

The Suctoria (also known as Acinetaria) form a group of very peculiar, highly specialized protozoans, formerly classified as a subclass of the Ciliata or Infusoria, but now usually placed in a class by themselves coordinate with other main groups of the Protozoa. The members of this class are distinguished from other Protozoa by the fact that the adult organism possesses sucking tentacles that are used, in the absence of a mouth, for both the capture and ingestion of food. The organisms are sedentary and may be attached to various objects, both living and non-living. Some species attach themselves indifferently to living or lifeless objects, others are found only on living organisms, and frequently live only on some particular animal and, sometimes, only on a particular organ of that animal.

The Suctoria are frequently found attached to Crustacea of various species but, so far as I can discover, have not previously been reported from fish.

One of the most remarkable characteristics of the Suctoria is the complicated life history. They may reproduce, like other Protozoa, by simply dividing into two similar individuals (binary fission) but usually multiply by the production of ciliated embryos which are formed by a process of budding. The young may be produced on the surface of the parent organism or they may develop in a brood sac formed from a deep depression of the body surface. In either case, they are totally unlike the parent being rounded and provided with cilia by means of which they may swim about for a time. Eventually the ciliated larvae become attached to a suitable object, lose their cilia, develop tentacles and grow into the adult form. The enormous numbers that occur on the gills indicate that under favorable conditions they must multiply very rapidly.

The species found on the bass does not develop a stalk for attachment as in the case of the majority of the Suctoria. On the contrary, it is attached to the surface of the gill by a broad base which is closely applied to the epithelium. The organism is not visible to the naked eye, but under the microscope appears as a slight mound or elevation on the surface of the gill filament from which projects a number of tenacles, the latter resembling long, rod-shaped bacteria.

The parasite can be more easily distinguished after the gill has been removed from the fish a short time and has begun to fade. They can then be seen as rounded bodies, about 30 to 40 microns in diameter, with a distinct orange color. The color is due to the presence of relatively large deep yellow or orange granules in the interior of the parasite. In some cases these granules may be absent, the organism then appearing colorless and transparent. In these rounded parasites the tenacles are usually not distinguishable, having been retracted into the body.

When the gills are examined immediately after the death of the fish, the parasites are usually more or less elongated with the tentacles attached at one end. At this time they are applied more closely to the surface of the gill and consequently are not as easily distinguished as after they have contracted and become more rounded. Due to the small size and transparency of the gills, the parasites can be more easily seen on fry and small fingerlings than on larger fish.

The great majority of the parasites are attached to the surface of the lamellae although a few may be found on other parts of the gill filament. They are by no means evenly distributed on the lamellae, fully 90 percent being located on the outer half. Here they may be so abundant as to form an almost continuous layer over the surface of the epithelium. In this position they are continually bathed by a fresh supply of water as it passes out between the gills, and are in an advantageous position to capture any plankton organisms that may be floating in the water.

It is by no means certain that the organism is a true parasite in the strict sense of the word. On the contrary it seems probable that the gills of the bass serve primarily as a means of support, and that the organism derives its chief nourishment from small animals in the plankton rather than from the fish. There are many organisms that are on the border line between true parasites and more or less harmless species which attach themselves indifferently to larger animals and plants or to inanimate objects. It is easy to see how such organisms may eventually become parasitic and it is, obviously, very difficult to draw a hard and fast line between the two types. As previously indicated, this is notably the case with the great majority of the Suctoria and as a group they seem to occupy the twilight zone between parasites and non-parasites. Some are unquestionably true parasites, others are just as definitely not parasites although they may at times accidentally become attached to living animals and plants. However, when dealing with organisms, such as many of the Suctoria, which are found only on certain species of animals - and this appears to be true of the form found on the bass - it is more logical to class them as parasites, although recognizing the fact that they have not yet become completely adapted to a truly parasitic mode of life.

Since there is no evidence that this organism derives its sustenance from the gill tissues the injurious effect on the host appears to be due primarily to irritation and interference with respiration, which must be considerable when the parasites are as abundant as on many of the fish examined. One of the most characteristic responses of fish to an irritating agent is a marked thickening of the epithelium. This not only interferes with the free exchange of gases between the water and the blood, but the outer epithelial cells become so far removed from the blood vessels that they are no longer properly nourished and become an easy prey to bacteria and fungus.

In heavily infested bass, the outer ends of the filaments become enlarged and club-shaped. Later, the enlarged ends become necrotic and fungus develops, forming a mass of felted fibers to which cling particles of silt debris thus giving the appearance of a dirty white mass attached to the ends of the gill filaments. The zone of thickened epithelium extends gradually toward the base of the filaments, followed by a similar extension of the necrotic area. As the soft tissues of the gill filaments disintegrate, the more resistant cartilaginous skeleton is left for a time

but, eventually it, too, is destroyed. Below the necrotic area is a light colored mass of tissue which increases on its inner side by rapid proliferation of the epithelial cells and at the same time disintegrates on the outer side, as the necrotic area steadily advances toward the base of the filament. It is not yet clear, however, whether the development of fungus follows or precedes necrosis. As a result, we find that in late stages of the disease large areas of the gills have been destroyed, the tissues having been replaced by a mass of debris and fungus fibers attached to the remains of the gill cartilages.

The parasites were noted only on bass in one pond at the Leetown station. In this pond the mortality started the second week in May and continued until the fish were removed and treated on the 29th. The dead fish were usually found near the inlet pipe. Both brood fish and fry suffered serious losses before the cause of the trouble was discovered. In several instances the fry died before leaving the nest.

As soon as the cause of the mortality was determined, the fish were removed from the pond and dipped in a 1-2000 solution of copper sulphate for one minute. At this time a number of brood fish were discarded since the gills were so badly affected that it seemed there was little possibility of recovery. Nearly all the treated fish recovered and showed no further evidence of infection.

Later in the season, E. W. Surber found the same parasite on fingerling bass at the Maryland State Hatchery at Lewistown. These fish suffered a heavy mortality which was undoubtedly due to the presence of Suctoria on the gills.

As previously mentioned, I have been unable to find any reference in the literature to the occurrence of Suctoria on fish. However, in May, 1931, Suctoria were found on the gills of brook trout sent to me by R. F. Lord from a private pond near Mendon, Vermont. The gill filaments were badly swollen, so much so in fact, that Lord reported that many of the fish were unable to close the gill covers. There was no evidence of necrosis or fungus and the filaments presented a somewhat different appearance from that characteristic of bacterial gill disease. The parasites were quite similar to those on bass but, since only material preserved in formalin was available for study, it has not been possible to determine if it was the same species. The presumption is, however, that it was not since each species of Suctoria is usually restricted to one host or, at most, to a few closely related forms.

It was thought at the time that this infestation was probably a case where, due to exceptionally favorable conditions, an organism which normally lives attached to inanimate objects had become so abundant as to attach itself to fish as well. Such cases occur occasionally with Protozoa belonging to other groups.

In view, however, of the occurrence of Suctria in such abundance on the gills of bass, it appears probable that there are species of these organisms that normally live on fish and, under certain conditions, are capable of causing serious injury to the host. That they have not been reported from fish previously may be due to the fact that they are very delicate animals, easily destroyed and by ordinary methods of preservation would be so contracted that their true nature would not be recognized. I have occasionally seen Suctoria on the gills of trout from various sources but, with the exception of the fish from Mendon, they were so few in numbers that their presence was considered purely accidental.

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Studies of the species on bass are being continued in the hope that the life history may be worked out and further information gained regarding the effect of the parasite on the host and the best methods of control. This preliminary account is published primarily for the purpose of calling the attention of fish culturists to the parasite, so that more information can be obtained regarding its occurrence at hatcheries throughout the country. It scarcely seems probable that it is confined to two hatcheries, one in West Virginia and the other in Maryland.

The writer will be glad to examine material from fish which show any indication of being infected with this parasite. In the case of adult fish, the gills should be removed as soon after the fish is killed as possible and preserved in a 10 percent solution of formalin (1 part formalin to 9 parts water). Fry or fingerlings may be preserved entire in formalin but, if possible, they should be placed in the solution while still alive. Since there is reason to believe that the parasites drop off or disintegrate within a short time after the death of the host, it is useless to send fish for examination that are found dead in the pond. Mr. Surber was unable to find the parasites on the gills of dead fry although they were invariably present on the gills of living fry from the infected pond.

COMMENTS FROM OUR READERS

SOME RECENT WORK ON FATTY LIVERS IN TROUT

I WOULD like to bring to the attention of trout culturists some recent work I have been doing on trout diets during the last few years which though still incomplete, is far enough along to be of use and I hope it will be of as much service to others as it has been to me.

Fatty livers in trout are well known to all hatchery men but it is not so well understood that there are many stages of this difficulty which escape observations. Only a careful examination discloses the abnormal liver conditions which are responsible for so much of the disease and trouble in the hatchery. I have not found that any serious study of fatty livers in trout has been made up to this time. As this difficulty was present among my own fish, I decided to investigate the subject to find out its real cause.

A chemist by profession, I naturally chose a chemical study first rather than a microscopic one, where I was not especially skilled in the technique. A detailed description of the methods used and the analyses made will be published in an appropriate place. Here, a summary of the results is all that is required to bring out the facts which are of importance to trout raisers. The livers of wild trout, healthy hatchery trout, sick and dead trout, were examined and analyzed.

Two kinds of fats were found in the livers. One readily extracted with ether, and the other which resisted ether and came out with alcohol. The ether fats are those of the ordinary kind, while the alcohol fats are those which are so combined in the cells that they will only extract with alcohol. The two together make up the total fats. Besides the fats, I determined the cholesterol esters which are fats combined with one of the solid higher alcohols. These are known to be present in larger than normal amounts in many diseased livers.

In wild trout the total fats were 21.25 to 23.50 percent of the dry liver material. These were composed of from 8.60 percent to 11.24 percent of ether extractable fats and from 12.51 percent to 13.62 percent of alcohol extractable fats. The alcohol fats were always found to be higher than the ether fats. This is taken to indicate that the diet of wild trout does not supply more fats than the trout can consume, and that there is not enough to provide a very large fat storage in the liver. The cholesterol esters varied from .26 percent to .33 percent and were never higher than this. These analyses were regarded as those of normal trout.

The livers obtained from hatchery trout showed very wide variations. Those fish whose livers approximated the analyses of those of wild trout gave far better results in the hatchery, the mortality was less, and the growth better, and diseases much less prevalent. Where the total fats exceeded 28 percent and to over 30 percent the mortality was higher, and the growth less. In many cases the ether fats greatly exceeded the alcohol fats indicating that the trout were getting an excess of fats in their diet which was being stored in the liver. Only in two or three cases were the cholesterol esters as low as those of wild trout. They ran from .40 percent up to as high as 1.60 percent. In most cases where the esters were over 1.0 percent the fish were doing badly.

Sick and dead trout all showed high cholesterol esters in the livers usually over 1 percent and higher. The fats were generally over 30 percent and in one dead trout 39 percent.

At this stage of the investigation it looked as if high fats and high cholesterol in the diet were the cause of fatty livers, and that this would prove the explanation required. However, no sooner had I reached this point of view, than a number of samples arrived from some very large hatcheries in which the fats were found to be over 30 percent in the livers and the cholesterol high, well over 1 percent. The fish in these hatcheries had shown a very low mortality over several years and the growth rate was high and they were producing large numbers of large trout. As there were several million of these fish, there could be no mistake about the facts. The livers themselves showed no sign of fatty degeneration under the microscope, but were a little too light colored and slightly enlarged. Evidently the diet of these fish was different in some respect from that of the fish tested so far. Examination of the diet revealed the fact that it contained a high percentage of vitamin "C", considerably higher than in the diets of the sick fish and of those which were not doing so well. Vitamin "C" seemed from this the most probable cause of the differences noted.

Fortunately I had at my hatchery a trout which had been fed on a diet of all dry food with Hewvita (phosphorized fats) for over a year. He was not well, and would not have lived for more than a week or so. He was fed the same diet with synthetic vitamin "C" added, suspended in salmon oil, at the rate of .7 milligrams per pound of trout a day. He began to eat well after a day or so and has been gaining weight and now looks in good health. Two more lots of trout which had been on the same diet for 7 months were treated in the same way, and they also began to grow again. These tests seemed to indicate that vitamin "C" was the missing necessary element in the diet. All the other trout in the hatchery were then fed the same diet and the results were marked immediately, the fish became thicker and deeper, the mortality stopped, the growth rate almost doubled and the diseases, such as fin rot, which had been prevalent for a number of months ceased in two weeks. I considered this good proof that Vitamin "C" was a necessity in trout diets.

The literature on scurvy, which is the disease caused by a deficiency of vitamin "C", was examined and only one account of scurvy in animals found. This was entitled "Studies on Scurvy" by Meyer and McCormick, Stanford University Press. This study related to the effects of vitamin "C" deficiency in guinea pigs. No facts on scurvy in fish have been published so far as I have found. Guinea pigs were found to have symptoms very similar to those I had noted in trout. Fatty livers with marked degeneration and yellow color, ulcers in various places, small hemorrhages at various points, especially in the intestinal cavity, and marked anaemia. This made it clear that trout with a deficiency of vitamin "C" suffer from scurvy, and that the symptoms are similar in many respects to those shown by animals. The ulcer disease of trout is probably due to scurvy. This is made more probable by the fact that it is cured by placing the fish on an insect diet which is high in vitamin "C". As "C" has been found to be a highly anti-infective vitamin it is quite likely that many of the trout diseases may arise from a deficiency in the diet. I feel quite sure that this is the case

I do not yet know exactly what the vitamin "C" requirement is for trout, but the studies so far indicate that it is from two to three times more than the accepted requirement for mammals. The only way to determine this accurately is to feed vitamin free diets with the pure vitamin added in various quantities and note the results. Such experiments are under way now but will take many months to complete. In the meantime it is thought that .7 milligrams per pound of trout per day is an ample amount for health. It is possible that this figure will prove too high, but if so, it will do no harm because vitamin "C" can be fed in excess without danger, as it passes off in the urine if the quantity is too great. Because of the rapid oxidation of vitamin "C" it is only possible to guess the amount trout get in their food in the hatchery. Only actual analytical tests of the food as fed, will give any accurate information as to how much vitamin "C" trout are actually getting in hatcheries. Tables are given at the end of this article showing the cholesterol and vitamin percentages determined so far. Other tests may be published as they are made.

The conclusions reached from feeding experiments and laboratory work so far may be of interest to others.

It does not make any real difference what the source of the protein fed to trout may be, so long as it will split up in the digestive processes into all the amino acids. These are the building blocks of the tissues. Variety is only necessary to make sure that the full number of amino acids can be derived from the protein. It is the accessory materials such as the vitamins, fats, cholesterol and mineral salts which determine the suitability of trout foods if the amount of protein is sufficient. The carbohydrates are sufficient in all the foods used.

The actual quantity of the high protein foods fed to trout is of the greatest importance. It must be proportioned according to the water temperature and the time of year. Never more than 1.25 percent of the weight of the trout should be fed in dry food material a day. Less than this is usually much better and safer. Trout can only make use of the actual food which their livers can work up for the blood stream, but they can dispose of a very much larger amount and such excess is harmful because the digestive apparatus is overloaded.

Diets high in fats should be avoided. A fat content of from 5 to 8 percent is as high as trout should have for best health.

A diet high in cholesterol is liable to be injurious unless it contains ample vitamin "C". Even so, it is not safe to feed a high cholesterol diet for any length of time.

Vitamin "C" must be present in ample amount. The excess can do no harm and deficiency leads to all sorts of complications.

A diet which has produced livers in hatchery trout precisely like those of wild trout in three separate hatcheries is composed of two parts fresh beef liver or sheep liver, and three parts of my balanced food by weight. This supplies a diet low in cholesterol with the right fats, and ample vitamin "C". The growth rate has been excellent and the mortality extremely low.

Liver alone has long been regarded as one of the best and most reliable trout foods. It does not however, produce normal trout as anyone who has eaten liver fed trout can testify. Such fish also lack vitality and stamina.

The reason for this is now clear. Liver contains about 28 percent fats in the dry material which is too high. It is also too high in cholesterol for a steady diet, to produce trout with normal livers. It contains ample vitamin "C" and this enables the fish not to get degenerated livers except occasionally. This is the chief reason why liver is such a good trout food. It also contains other vitamins and necessary substances. Liver is therefore a very valuable food but should be used as part of the diet only, combined with foods low in cholesterol and fats. Used in this way, it makes the best trout food available.

The tests used in determining vitamin "C" are simple and easily completed in ten minutes. The trouble is that the solution employed is not easily standardized and will not keep long. I hope to be able to have a simplified method which hatchery

men can use for the determination of the vitamin in the food they use. Such a method would add greatly to the assurance of success in hatchery work.

I hope that the discovery of some of the causes of fatty livers and the fact that Vitamin "C" is necessary in trout diets and its deficiency a potent cause of disease and death, will prove of real service to the trout culturists of this country.

TABLE OF ANALYSES

	Per Cent Cholesterol.	Milligrams Per Gram Vitamin "C".
Dry beef liver	.89	.60 - .80
Dry beef liver (frozen 12 hours)	.89	.50
Dry beef liver (frozen 3 days)	.89	.35
Dry sheep liver	.50	.56
Dry pig liver	1.13	—
Fresh sheep heart	—	.06
Dry beef heart	1.86	—
Dry pig heart	1.04	—
Pig melts	.889	—
Dry beef melts	1.38	—
Dry beef lights	1.45	—
Hamburger (Fresh)	—	.027
Calves brains (Fatal to trout)	5.21	—
Dry haddock roe	.95	—
Fresh flounder flesh	—	.30
Fresh salt water shrimp	—	.34
Dry salt water mussels	.72	—
Dry herring	.665	.0
Dry menhaden meal	.612	.0
Salmon egg meal (Pure)	.849	.0
Salmon egg meal (as bought)	.70	.0
Salmana (Dry salmon waste)	.37	.0
Dry skim milk	.028	.0
Balanced trout food (E.R.H.)	.40	.0
Tubifex fresh, figures on dry basis (Small Annelid water worm)		.49
Ascellus, (Fresh, figures on dry basis)		.80
Crane fly larvae (Fresh, figured on dry basis)		2.69
Live fresh trout liver (apparently well)		.38
Live trout liver of ulcer trout		.10
Fresh well trout spleen		.27

Edward R. Hewitt

8280

NOTES OF FINGERLING TROUT

Editor, Progressive Fish Culturist:

Although I am but a novice at the business of fish propagation--which was wished on me in the form of a White Elephant-- it affords me real pleasure to let you know how very much I appreciate The Progressive Fish Culturist, your editorials and the constructive information which the publication contains.

Living as I do on a stream which, forty years ago, seemed to support an inexhaustible supply of Brook trout and which at the present time is practically barren of fish, in spite of the fact that thousands have esacaped from my ponds within the past three years owing to my inexperience regarding their uncanny methods of contriving to make a clean and trackless get-away, I have some understanding of the problem.

In this connection I hope you can imagine the interest I had in Mr. Fred J. Richans' article in the October issue and the ensuing comment by Mr. Timmens and yourself. To me it was indeed refreshing to see a Government man spill his mind in so practical a manner.

I have had plenty of mighty expensive experience in attempting to keep my ponds supplied by buying and transporting fry and/or fingerlings only to be forced to give it up on account of distance. Am now buying eyed eggs and hatching them on the premises. Dec. 27 last I placed 25,000 Brook eggs in my hatchery which were purchased not so far from the Glacier National Park; today, although they were all hatched some time ago, the count of bad eggs and dead fish is just exactly 400. Some record I believe. (Perhaps I had better add that I did the counting myself.)

Reports of fish disappearing from this and that pond I took at its face value until I learned for a certainty where my own fish were going. Since I caught them in the acts of their elopement I have my doubts as to the correctness of some of the reasons advanced by others to account for the loss of fish from ponds. In one instance 8 to ten-inch trout would not jump one to four inches from one pond to another but were mightly adept at jumping over an eighteen inch concrete wall into a header and therefrom swim into the open creek. Tricks resorted to by fry and fingerlings are too numerous to mention. Neighbors opined that my fish were being stolen and if I had let it go at that I should, perhaps, never have discovered the truth.

Ousels do catch some fingerlings but, since they pick them to pieces rather than swallow them whole, their stomachs do not tell all the story. One lone kingfisher gave trouble for a while and had fish bones in its stomach but I would like to know what became of the thousands of fish which escaped into a half mile of creek and disappeared--they did not go down stream because they could not. A careful and systematic search of this branch resulted in a find of just eighteen fish.

$250

In the matter of water supply I probably have one of the best in the U. S. for trout. The water is exceptionally clean and pure; max. temperature in summer is 52 and in winter the minimum with outdoor at -35 is 46. With this advantage it follows that I can better understand all reference to the subject so ably discussed by Mr. Richans. Further, while I am a novice at commercial production, I have seen planted or helped to plant many thousands of fish in the creek of which the spring branch upon which my hatchery and ponds are located is a tributary, I can but hope that the time is near when more attention will be given to what becomes of the millions of fry which are sacrificed by the present system of planting.

Thanking you for every single copy of P.F.C. and with best wishes for your success, I am

Sincerely yours,

Wm. Mosteller,
Casper, Wyo.

Editor's Note: Readers are referred to the P.F.C. for January 1936, No. 14, p. 26, for one solution of the problem of preventing trout jumping at the head of troughs.

NEED OF IMPROVEMENT IN STOCKING METHODS

Editor, THE PROGRESSIVE FISH CULTURIST:

I am intensely interested in the articles appearing in THE PROGRESSIVE FISH CULTURIST regarding the planting of fish, especially the article of Mr. Richan in the October issue and the letters from Mr. Timmens in the December issue. All the articles contained in the above mentioned issues of the magazine are, in my opinion, absolutely right in so far as they call attention to the great need for a planned fish distribution policy. But there is one thing I have noticed about a large part of the articles on the subject of a planned fish planting program. This seems to be a tendency to place the responsibility, or one might say the blame, for the lack of such a policy and the improper planting of fish, at the door of the hatchery superintendent, whereas the present antiquated system of honoring private applications, following meager and oft times inaccurate information, is largely responsible. In most instances the writers have failed to bring forward any workable plan to solve the problem.

My experience during a number of years engaged in fish cultural activities of the Bureau of Fisheries in the Mountain States has, through my contacts with persons in charge of both State and Federal hatcheries, shown me that contrary to what appears to be current opinion, these persons are very much interested in where their charges are planted and of what becomes of them after they are liberated. The question might arise, "Why is not something further done about it, and why is not an intensive effort made to right the condition?" A short answer to that question might be, "The working day is not sufficiently long, and if it were, the fish culturist in most cases would not be qualified for properly doing the work." The duties of a person in charge of a State or Federal fish hatchery, and in fact the duties of the

entire personnel of such hatcheries, are very numerous and would certainly not allow the vast majority of hatchery superintendents or their personnel to make investigations regarding the planting of fish in any waters of their territory outside of the streams directly adjacent to the hatchery. Most state hatcheries have a large distribution area. The Federal hatcheries have distribution areas extending a radius of several hundred miles from the hatchery. In most cases it would be absolutely impossible for the hatchery superintendents or their employees to go over all the waters in their particular area and work out a stocking policy for each individual body of water and see to the actual planting of all the fish.

I believe that one is safe in making the statement that 100 percent of the persons engaged in public fish culture deplore the planting of fish by inexperienced sportsmen, introduction of exotic species, the overstocking and understocking of streams, and so on. An instance comes to my mind whereby a certain body of water was stocked with a species of warm water fish over the protest of a State hatchery superintendent and myself. This particular body of water was beyond question ideal trout water, but the sportsmen demanded the other species and our opinion was given no consideration. Every hatchery superintendent can no doubt recall similar experiences. The sportsmen must be convinced to the need for a change of policy. The duties of the fish cultural establishments are to raise fish and this they do with ever-increasing efficiency. It would appear that any further effort or available time should be devoted to improvements in fish culture itself.

We now come to the question of what shall be done regarding the situation. In my humble opinion the question is answered by Carl L. Hubbs of the Institute for Fisheries Research, Michigan Department of Conservation, in his article in the October 1936 issue of THE PROGRESSIVE FISH CULTURIST. The duties of the fish hatcheries appear to be well defined. It seems that stream management to a certain extent is a field apart from fish culture. It is going to be necessary to have trained technicians in each fishing district of a State--men who are trained in biology and who could determine the special needs of each body of water and actually supervise the planting of the fish. The areas probably should be rather small so as to allow for each body of water to be investigated each year or two as the needs of a stream vary greatly from numerous causes. Several years ago the Bureau of Fisheries inaugurated a limited program of planned trout distribution by the employment of several Regional Fish Culturists whose duties were to outline fish planting programs in the National Forests. But even this modest effort toward solving the planting problem was of necessity stopped when appropriation cuts came along.

All public fish culturists are fully aware that the ultimate destination of our fingerling fish should be the fisherman's basket. It seems to me that the proper procedure to follow in lessening the mortality from the time the fish are planted and the time they are removed from the stream by the angler, is to make a concerned effort toward convincing the sportsmen that a stream management program will yield greater results than the present haphazard planting by individuals and organizations.

Charles L. Fuqua, Foreman In Charge
U. S. Fisheries Station
Spearfish, South Dakota

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NOTES AND NEWS

FISH CULTURE GOES COLLEGIATE IN MONTANA

Through the interest and efforts of Dr. C. J. D. Brown, Instructor in Zoology at the Montana State College, an instructive and practical innovation was introduced into fish cultural activities in Montana. This comprised a six day course given by Dr. Brown at the college from December 7th to 12th, inclusive.

The course was conducted by the combined lecture and laboratory method. Texts used were, "Field Book of Ponds and Streams," by Ann Haven Morgan, Professor of Zoology, Mt. Holyoke College, "Guide to the Study of Fresh-water Biology", by Needham and Needham and outlines prepared by Dr. Brown. The first mentioned is highly recommended. It is of pocket size, easily taken on field trips to aid in identification of aquatic life. The illustrations are numerous, beautifully colored and labeled and taken from life photographs.

Classes convened at 8:00 a.m., and except for an hour at noon continued throughout the day, dismissing at 5:00 p.m. One social noon hour was held and very much enjoyed. Each person brought a pocket lunch; free coffee was served.

The lectures, which preceded the laboratory work for each subject handled, were very interesting and instructive.

The microscopic work was especially interesting and included the identification of fish food organisms, study of scales and ear bones for the determination of the age of the fish and the examinations of the stomach contents of fish.

The course was attended by eight representatives from the Montana State Fisheries, two from the Gallatin National Forest, one from the Custer National Forest, one from the Regional Office of the Forest Service and three from the Bureau of Fisheries Station at Bozeman. Aside from the valuable instructions received which cannot be fully estimated now, as it has aroused an interest and insight that will carry on in the future, the course made for better understanding and cooperation between the three organizations largely responsible for fish distribution in Montana.

A committee of three, one from the Montana State Fisheries, one from the Forest Service and one from the Bureau of Fisheries was appointed, with Dr. Brown acting in an advisory capacity, the purpose of which to meet at different intervals for the correlation of a fisheries management program in Montana, which when completed, is to be presented to the administrative offices of the above mentioned departments with recommendation of acceptance or revision.

H. F. Johnston
U. S. Fisheries Station
Bozeman, Montana

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DEATH OF HARRY F. JOHNSTON

In recording the death on February 4, 1937, of Harry F. Johnston, superintendent of the Bozeman, Mont., station, the usual expressions of loyalty and efficiency would be warranted in the fullest measure. These statements, however, would fall far short of rendering a just tribute to a personalty which endeared itself to all who knew him.

He entered the Bureau's service in 1914 as car laborer. In 1917 he resigned to enter military service, and was reinstated in 1919, again resuming the duties of a car messenger. He became car captain in 1925. His activities on the fish cars from the date of his appointment until 1928 when he became foreman of the Leadville station, brought him a wide acquaintance among the Bureau's field personnel. After his service at Leadville he became superintendent of the Afognak, Alaska, station, returning to the States as superintendent at Bozeman in 1932.

Mr. Johnston was slightly over 40 years of age at the time of his death, which apparently was caused by injuries contracted in the line of duty.

Fisheries Service Bulletin
March 1st, 1937. No. 262
Washington

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